Clinical significance of free-floating venous thrombi

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To evaluate the fate of free-floating venous thrombi, venous duplex scans of 5238 consecutive lower extremities over a 2½ year period were reviewed. Acute deep venous thrombosis was found in 732 cases. Eighty-two free-floating deep venous thrombi were diagnosed in 73 of these patients. Nine of 72 patients (13%) had pulmonary emboli as diagnosed by ventilation perfusion scanning or pulmonary angiography or both. Seven of these patients (78%) had a pulmonary embolus before the initial duplex scan. Two (22%) had a pulmonary embolus after the diagnosis of free-floating thrombus. Thirty-three of 73 patients (45%) had follow-up of free-floating thrombi by duplex scanning performed in the acute period (less than 30 days): 18 (55%) showed attachment of the free-floating thrombus, three (9%) showed progression in size of the free-floating tail, and eight (24%) showed decrease in size or resolution of the free-floating thrombus. Four (12%) showed persistent thrombus without evidence of resolution, propagation, or attachment. In conclusion, free-floating venous thrombi occurred in 10% of cases of acute deep venous thrombosis. Only 13% of free-floating thrombi were associated with clinically significant pulmonary emboli, confirmed by ventilation perfusion scanning. Usually the embolus occurred before diagnosis of free-floating thrombus. Most free-floating thrombi followed noninvasively by duplex scanning do not embolize, but rather they become attached to the vein wall or resolve. (J VASC SURG 1990;11:62-9.)

The recognition of free-floating venous thrombi is increasing as a result of increased use of duplex scanning for venous imaging. Intuitively, one would expect long, proximal free-floating venous thrombi to be more likely to form embolus than short, distal, attached thrombi.

Based on this premise, several authors have advocated venous thrombectomy, vein ligation, or vena cava interruption for free-floating venous thrombi.[1-3] Neither the natural history of untreated free-floating venous thrombi nor the fate of free-floating thrombi treated by standard anticoagulation has been documented.

This article is a retrospective review of all lower extremity venous duplex scans obtained over a 2½-year period to determine the incidence, natural history, and clinical significance of free-floating venous thrombi.

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MATERIAL AND METHODS

From January 1986 to July 1988 deep venous thrombosis (DVT) was diagnosed in 2061 extremities by means of duplex ultrasonography. By the ultrasonic criteria listed in Table I, thrombi were classified as acute, chronic, or indeterminate in age. The indeterminate-age group includes thrombi of mixed character that were not predominately acute or chronic. Seventy-three (10%) of 732 cases of acute DVT identified had free-floating thrombi. Characteristics of this cohort are summarized in Table II. These 73 patients had 82 free-floating thrombi.

Thirty-three of the 73 patients (45%) had follow-up scanning during the acute period of 30 days. These cases permit evaluation of the clinical fate of treated and untreated free-floating thrombi. The outcomes of these thrombi were categorized as attached, disappearing, propagating, or stable.

For purpose of discussion, the lower extremity is divided into a series of zones (Fig. 1). In the average adult each zone is approximately 10 cm in length. The location of each thrombus and its free-floating segment was recorded by the interpreting physician on a diagram similar to that in Fig. 1. This diagram was used to categorize the length and location of each free-floating thrombus.

Pulmonary embolism was diagnosed on the basis of positive ventilation/perfusion scan or pul-

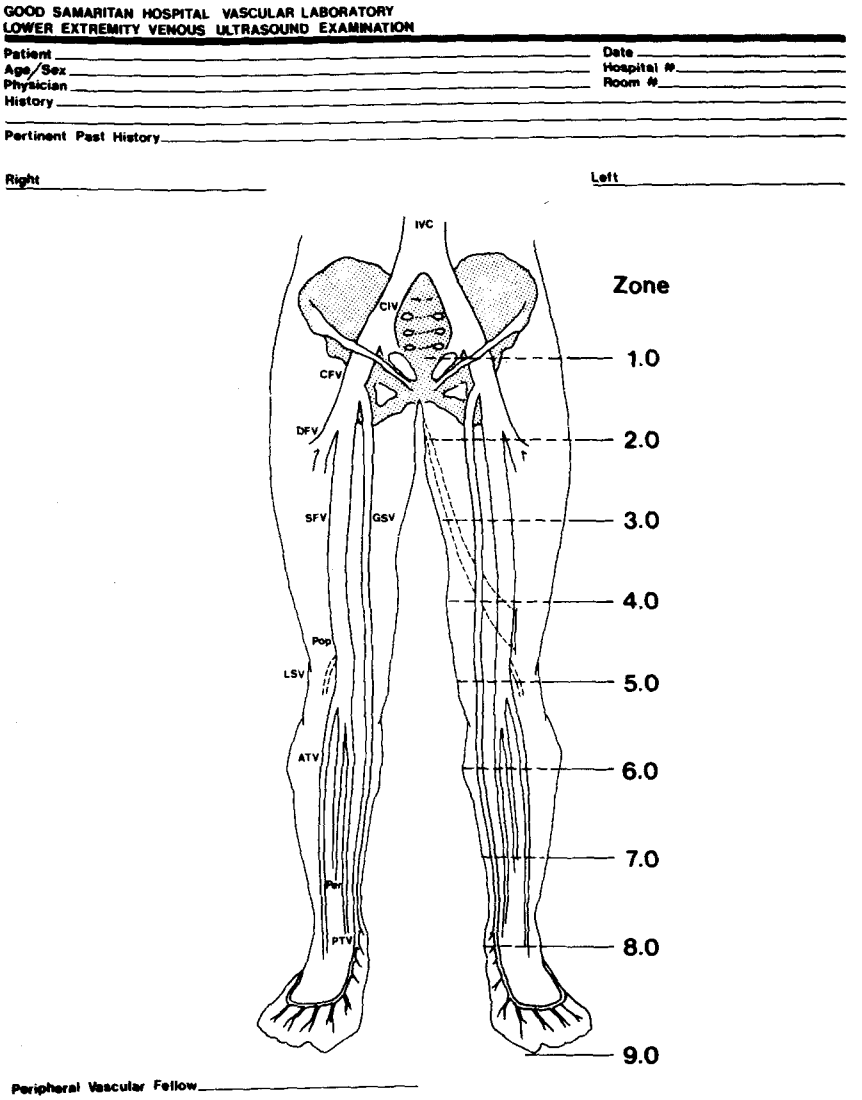

Fig. 1. Zones of reference for lower extremity venous scanning. (Reprinted with permission from Karkow WS, Ruoff BA, Cranley JJ. B-mode venous imaging. In: Kempczinski RF, Yao JST, eds. Practical noninvasive vascular diagnosis. 2nd ed. Chicago: Year Book Medical Publishers, 1987)

showed attachment of the free-floating tail. The timing of the follow-up scans obtained in this group ranged from 3 to 17 days (mean, 7 days). Two of the 18 patients had pulmonary emboli, but both occurred *before* the initial duplex scan.

Eight (24%) of the follow-up scans showed either a decrease in size or total resolution of the free-floating thrombus. One pulmonary embolus was diagnosed in this group *after* the initial diagnosis of a free-floating thrombus. Although disappearance of the free-floating thrombus in this case could be associated with the pulmonary embolus, in no other case was there clinical suspicion or confirmed diagnosis of pulmonary embolism.

Three (9%) of the follow-up scans showed progression in the size of the free-floating thrombus. These patients were restudied from 1 to 4 days after the initial scan was obtained. One 10 cm to 20 cm free-floating femoral thrombus propagated into the iliac vein, but no pulmonary emboli were recognized in this group of patients.

Four of the scans (12%) showed persistent free-

Table I. Clot characteristics: relative value in clot aging

Characteristic	*Acute value*	*Chronic value*
Degree of occlusion	Total**	Partial**
Free-floating	Free****	Stationary**
Clot retraction	Retracted***	Adherent***
Clot distention	Distended***	Contracted**
Clot compressibility	Soft****	Firm*
Surface character	Smooth**	Irregular**
Echogenicity	Faint*	Bright*
Homogeneity	Homogeneous**	Heterogeneous**
Collaterals	Absent*	Present****
Recanalization	Absent*	Present****

From Kempczinski RF, Yao JST. Practical noninvasive vascular diagnosis. 2nd ed. Chicago: Year Book Medical Publishers, 1987:482.
Four asterisks indicate a diagnostic level; three asterisks, good; two asterisks, fair; and one asterisk, poor (nondiagnostic). Each asterisk indicates the relative value to be given to each criterion in interpretation of clot age; many criteria are only valuable when present, and the overall decision represents a weighted average.

monary angiography results. Chi-square analysis was used to evaluate the characteristics of free-floating thrombi and their association with pulmonary embolism.

RESULTS

Pulmonary embolism

Pulmonary embolus was not clinically suspected in 63 of the 73 patients (86%). A pulmonary embolus developed in nine patients (12%), which was confirmed by positive ventilation/perfusion scan or pulmonary angiography results. One additional patient was clinically suspected of having a pulmonary embolus but had no confirmatory studies. This patient had no follow-up duplex scan obtained and was excluded from analysis because of the inaccuracy of the clinical diagnosis.

Location

The locations of the free-floating thrombi are summarized in Table III. When free-floating thrombi were located in the iliac, common femoral, superficial femoral, and popliteal veins, the incidence of pulmonary embolism was 11%, 9%, 30%, and 17%, respectively. These differences were not statistically significant.

Size

The estimated lengths of the free-floating segments of the venous thrombi are summarized in Table IV. When thrombi <10 cm long were compared to those >10 cm, no statistically significant difference in frequency of pulmonary embolism was noted.

Table II. Characteristics of 73 patients with free-floating venous thrombi

Age	
Mean	68 yr
Range	43-90 yr
Sex	
Male	42 (58%)
Female	31 (42%)
Prior DVT	12 (16%)
Prior PE	3 (4%)
Malignancy	28 (38%)
Operation or trauma (<30 days)	23 (38%)

DVT, deep venous thrombosis; PE, pulmonary embolism.

Multiple versus single free-floating thrombi

Sixty-six patients (90%) had a single free-floating thrombus, six patients (8%) had two free-floating thrombi, and one patient (1.4%) had three separate free-floating thrombi. The incidence of pulmonary embolism was not correlated with the number of thrombi.

Treatment

Sixty-one of 72 patients (85%) were treated with anticoagulants alone. Five patients (7%) received no treatment after DVT was diagnosed. One patient had vena cava interruption because of pulmonary embolism and contraindication to anticoagulation. Another patient was treated with urokinase followed by heparin and had no clinical signs of an embolus during treatment. Four of the patients (6%) were initially treated with heparin but underwent subsequent vena cava interruption because of complications of anticoagulation.

Timing of pulmonary embolism

Seven of the nine patients (78%) with pulmonary embolism had the diagnosis confirmed *before* the initial diagnosis of a free-floating thrombus. Only two of the nine (22%) patients had pulmonary embolism *after* diagnosis of a free-floating venous thrombus. In these two cases, pulmonary embolism occurred at 8 days and 4 weeks, respectively.

Follow-up by duplex scan

Thirty-three of the 73 patients (45%) had follow-up duplex scanning of the free-floating thrombi during the acute period of 30 days. These follow-up scans were obtained from 1 to 17 days (mean, 7 days) after the initial study. Five of the nine patients with pulmonary embolism had follow-up duplex scanning, but four of the five had pulmonary embolism *before* the diagnosis of a free-floating thrombus.

Eighteen of the 33 follow-up scans (55%)

Table III. Location of 82 free-floating venous thrombi

Location	*No.*	*Percentage*
CFV/IV	8	9.8%
SFV/CFV/IV	2	2.4%
CFV	33	40.2%
SFV/CFV	8	9.8%
DFV/CFV	1	1.2%
SFV/DFV/CFV	1	1.2%
SFV	10	12.2%
PV	15	18.3%
PTV/PV	3	3.7%
PTV	1	1.2%
Total	82	100.0%

IV, iliac vein; CFV, common femoral vein; SFV, superficial femoral vein; DFV, deep femoral vein; PV, popliteal vein; PVT, posterior tibial vein.

Table IV. Estimated length of 82 free-floating venous thrombi

Length	*No.*	*Percentage*
<10 cm	61	74%
10-20 cm	17	21%
20-30 cm	4	5%
Total	82	100%

floating thrombus without resolution, propagation, embolism, or attachment. These scans were obtained from 4 to 10 days after the initial scan (mean, 6 days). Both pulmonary emboli in this group were diagnosed *before* the initial duplex scanning.

DISCUSSION

Venous duplex ultrasonography is a noninvasive modality that combines an anatomic (B-mode) and a physiologic (Doppler) study to provide accurate information about the venous system. Duplex ultrasonography can provide both direct evidence (visible clot, venous distention, and noncompressibility) and indirect evidence (such as presence or absence of Doppler flow signal, presence or lack of phasic signals with respirations, abnormal flow with augmentation maneuvers) of venous thrombosis. The accuracy of duplex venous ultrasonography has been well documented.[4-7] Overall, duplex venous scanning is approximately 95% accurate compared with the gold standard of venography in the diagnosis of DVT.[7]

Duplex ultrasonography can also be used to categorize venous thrombi as acute or chronic based on characteristics listed in Table I.[8-12] One characteristic, a free-floating tail, is "diagnostic" of *acute* DVT.[9] To be considered free-floating, a thrombus must be surrounded by a visibly patent lumen. During real-time ultrasonography the tip of the thrombus can be seen to waver during respiration or during gentle compression with the ultrasonic probe or both (Figs. 2 and 3).

The incidence of pulmonary embolus in other series of DVT treated by anticoagulation alone ranges from 9% to 22%, depending on whether or not calf thrombosis is included in the treatment group.[13,14] Kistner et al.[15] reported an overall 13% incidence of symptomatic pulmonary emboli in all cases of DVT. The presence of a free-floating thrombus was associated with a pulmonary embolus in 12% of cases in the present study. The rate of embolization in this study is not significantly higher than that reported in other series that include all cases of DVT.

Other authors have suggested that free-floating venous thrombi have a higher incidence of pulmonary emboli than do attached venous thrombi.[1,2,16,17] Norris et al.[16] reported that pulmonary emboli developed in 60% of cases of venographically-diagnosed free-floating iliofemoral thrombi; however, there were only five patients with free-floating thrombi in their series.[16] In a larger series of patients with vena cava thrombi, Radomski et al.[17] reported a higher incidence of pulmonary emboli with free-floating thrombi.[17] The incidence of pulmonary emboli in cases of common femoral and distal free-floating thrombi has not been previously documented. From the present series such thrombi may not be as ominous as previously suspected, and serial duplex scans frequently show attachment of the free-floating thrombus to the vein wall.

In the present series treatment consisted of heparin followed by oral anticoagulation with warfarin. No venous thrombectomies were performed, and vena cava interruption was used only when anticoagulation was contraindicated. Other treatment options include thrombolytic therapy, operative thrombectomy, venous ligation, and vena cava interruption.

Lytic therapy might, in theory, result in a pulmonary embolus. One patient in the present series was treated with urokinase for 48 hours, followed by heparin and warfarin. No pulmonary embolus was demonstrated and resolution of the free-floating clot was documented by follow-up duplex scanning.

Various forms of operative therapy have been advocated.[1-3] Thrombectomy would treat the immedi-

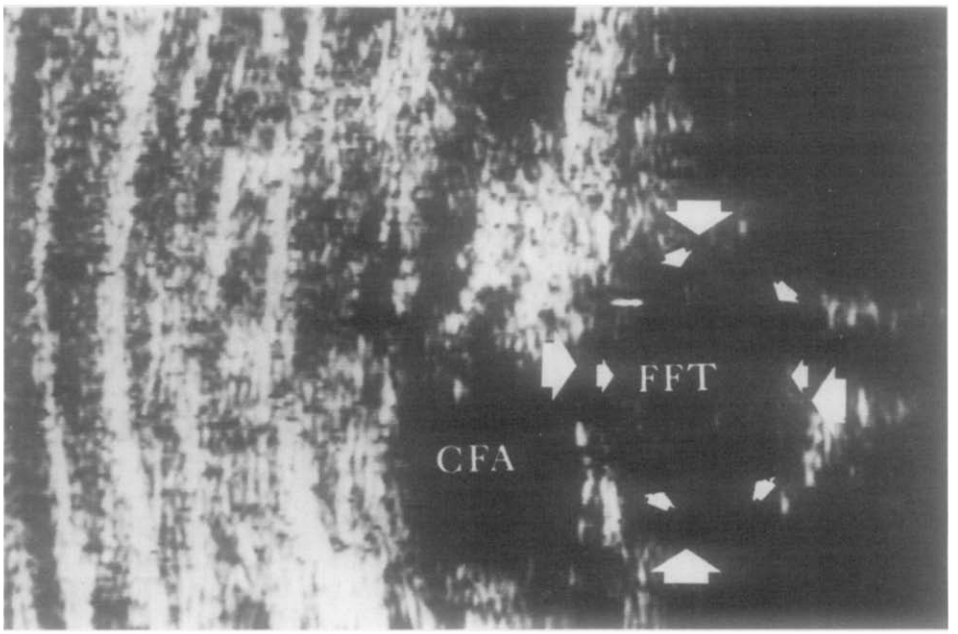

Fig. 2. Transverse view of free-floating thrombus *(FFT)* in common femoral vein. *Small arrows* indicate edge of thrombus; large arrows indicate vein wall. *CFA,* common femoral artery.

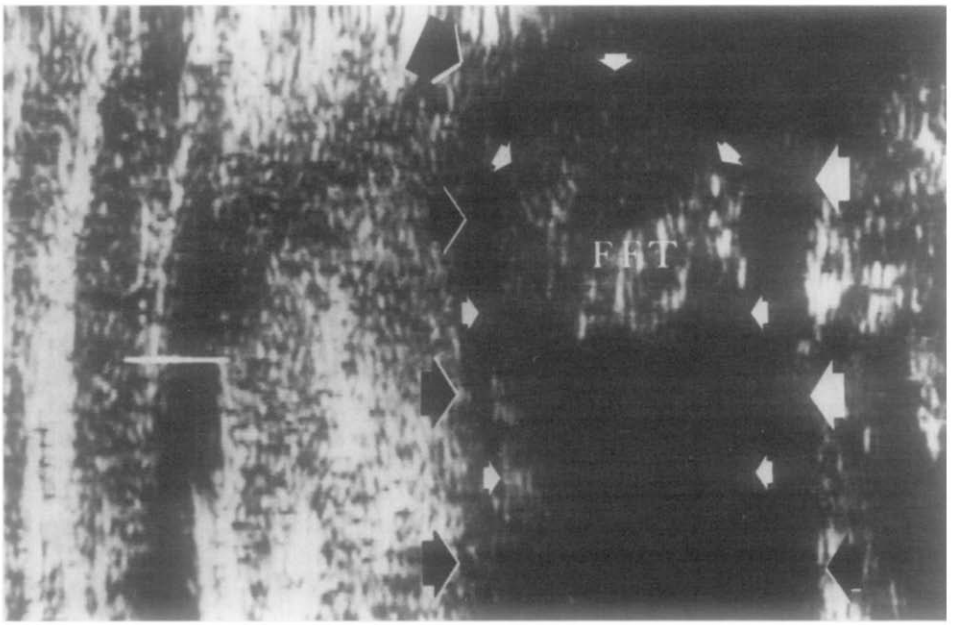

Fig. 3. Longitudinal view of free-floating thrombus *(FFT)* in common femoral vein. Note ball-shaped tip indicated by *small arrows; large arrows* indicate vein wall.

ate problem of the free-floating thrombus, but operative manipulation might also result in a pulmonary embolus.[18] Postoperative pulmonary emboli, which may be fatal,[19,20] have also been documented after thrombectomy.[19-21] In the operative series by Kistner et al.[15] of "loose clots," pulmonary emboli developed in 7% after surgery. In one of the largest series of operatively treated free-floating thrombi, Savelyev

et al.[1] reported a 1.5% incidence of recurrent pulmonary emboli after prophylactic operation.

Vena cava interruption in the presence of free-floating thrombus has been recommended for thrombi at or proximal to the femoral vein, which, in fact, represent 10% to 17% of the indications for vena cava filters.[3,22,23] In situations where anticoagulation is contraindicated, vena cava filtration is an excellent option because of its effectiveness and its minimal morbidity and mortality.[22]

Most pulmonary emboli are diagnosed before the diagnosis of DVT. Menzoian et al.[13] reported that in their experience 82% of pulmonary emboli preceded the diagnosis of DVT.[13] In the present series 78% of pulmonary emboli were diagnosed before the recognition of a free-floating thrombus. Because of the low incidence of subsequent pulmonary embolism, standard anticoagulation alone is recommended as appropriate treatment for free-floating thrombi.

The present study demonstrates that free-floating venous thrombi occur in 10% of cases of acute DVT. With the increasing use of duplex venous ultrasonography, clinicians will be faced with therapeutic decisions regarding free-floating thrombi. Although it is retrospective, the present study suggests free-floating thrombi do not have an increased incidence of pulmonary embolization. Furthermore, most pulmonary emboli will have occurred by the time the free-floating thrombus has been recognized. Based on this information, the authors do not advocate routine operative treatment of infrainguinal free-floating thrombi. Only in selected cases does the risk of major, potentially lethal pulmonary emboli justify vena cava interruption. The criteria by which such patients are selected for operative intervention in the face of free-floating venous thrombi remain to be defined.

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DISCUSSION

Dr. Lazar Greenfield (Ann Arbor, Mich.). I am grateful to the authors for the opportunity to review their manuscript and would like to compliment them on their study, since there is a great need for additional information on the risks and natural course of deep vein thrombosis.

In a previous study we reported in 1985, we sought to determine the relationship between the presence of a free-floating tail on the thrombus, defined as being at least 5 cm long and confirmed by contrast venography.

We conducted the study in such a fashion that the proximal tail could be outlined and then contrasted with the occlusive thrombus. We found it was important to define this tail as being at least 5 cm long.

In our series of 78 patients only five (7%) fulfilled the criteria, but three of them sustained subsequent thromboembolism on anticoagulant treatment. In contrast, only four of the 73 patients with occlusive thrombi sustained embolism for an incidence of 5.5%.

Although these numbers are small, additional reinforcement for the hypothesis came from a study reported by Radomski et al.[17] who found the presence of free-floating thrombi in the inferior vena cava to be associated with a 50% incidence of pulmonary embolism at the time of diagnosis, and 27% of their patients continued to embolize during subsequent treatment. Browse et al.[2] have shown that patients with embolism demonstrate residual free-floating thrombi in 38%.

Since the authors today have reached different conclusions on the basis of their study, it may be helpful to look at some of the differences in the study design. With the use of a biplanar contrast venogram, we could be reasonably sure that the thrombus was not adherent to the wall at any point in its circumference. It may be more difficult to reach this same conclusion with B-mode ultrasonography alone, and I ask the authors how they could be sure that the thrombus was not touching the wall at any point or that they were seeing all of the thrombus. Fresh thrombus has very faint echos, and vein compression may be the only way to identify it as documented in a recent article in the *New England Journal of Medicine*.

Also, it was our feeling that the tail of the thrombus had to be at least 5 cm long to have any mechanical significance, and since 74% of the authors' floating venous thrombi are described as simply being less than 10 cm long, I ask them how many were actually at least 5 cm long rather than being smaller protrusions.

Another concern is the adequacy of evaluation of the iliac extension of iliofemoral thrombi, since it is difficult consistently to image the iliac veins. How were patients with iliofemoral venous thrombosis handled in this study?

Next, how was the diagnosis of embolism made? The numbers of scans or angiograms were not specified in the manuscript. Nor do we know which patients received follow-up. Only 33 of 73 patients had follow-up duplex scans; how many were scanned for embolism? On the basis of many high-quality studies performed in the past, we know that about 10% of patients with DVT will sustain pulmonary embolism in spite of anticoagulation. We also know that emboli form in many patients silently, estimated in most studies to be in the range of 70% to 80%. Therefore, any study that draws conclusions about the incidence of embolism from symptomatic emboli alone overlooks most embolic events.

The authors also point out that pulmonary embolism developed in 78% of their series before the diagnosis of DVT, and I think that represents the strongest support for our hypothesis. The floating thrombus that does not interfere with flow does not produce venous hypertension and the clinical signs of DVT.

The conclusions regarding incidence of pulmonary embolism by thrombus location are based on chi-square analysis and an incomplete number of follow-up studies, but beside these limitations, five patients had vena cava interruption, which should have excluded them from the study.

Finally, the authors' own incidence of pulmonary embolism in 30% of patients with superficial femoral floating thrombi makes me wonder just how comfortable they would be with anticoagulation treatment alone in a patient at high risk for cardiac or pulmonary disease. If pulmonary embolism does not result from the detachment of free-floating thrombi, then perhaps the authors can tell us just where they come from.

Dr. Baldridge. I thank Dr. Greenfield for his comments. He has raised several points and questions. I will try to address them as best as possible.

In real-time imaging we are able to see lumen circumferentially around the thrombus, and the tip can be seen to wave back and forth, showing there is no attachment to a vessel wall.

It is true that it is difficult to give an exact measurement of each thrombus less than 10 cm long. Seventy-four percent were in that category. The width of the ultrasound probe is approximately 4 cm, and each of the thrombi considered "free-floating" was larger than 4 cm.

As far as classification of iliac thrombi, the only ones included in the present study were those that were obviously free-floating in the common femoral vein and could be followed proximally with the tip noted within the iliac vein. One thing different about our study compared to those of Dr. Greenfield and Dr. Radomski is that we are talking about more distal thrombi, generally free-floating thrombi in an infrainguinal location.

All nine of the patients diagnosed with pulmonary embolism had a high-probability ventilation/perfusion scan, and one of those nine had positive pulmonary angiography results. Five of these patients with pulmonary embolism were included in the group who had follow-up duplex scans. Two of the patients had pulmonary embolism before the diagnosis of the free-floating thrombus and follow-up

scanning showed attachment of the free-floating segment. Two additional patients had persistent free-floating thrombi in brief follow-up periods of approximately 3 days. In follow-up none of these patients had clinical evidence of further pulmonary embolism. Only one patient in our study had an embolus after the initial duplex scan and showed disappearance or resolution of the free-floating segment by follow-up duplex scanning.

Finally, although many prospective studies of DVT suggest pulmonary embolism occurs in over 50% of cases, most of such emboli are "silent." We question the significance of such silent emboli and the requirement for caval interruption in that group of patients. Currently, it is our practice at Good Samaritan Hospital that we do not interrupt the vena cava for prophylactic indications in cases of free-floating thrombi discovered by duplex scanning.

I thank the Society for the privilege of presenting this material.